NON-HEAT JOINING OF METALS

A Creative Problem in Lieu of Thesis

Presented to the Graduate Council of the
North Texas State University in Partial
Fulfillment of the Requirements

For the Degree of

MASTER OF FINE ARTS

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INTRODUCTION

The utilization of commercial sheet metals in the construction of sculpture has been in practice since the turn of the century. The Cubists and the Russian Constructivists began to explore the possibilities of this material, and it has been used by many contemporary sculptors.

Due to some recent personal conceptual and visual considerations I have been making, the use of commercial sheet metals has become important to the development of my work. By utilizing sheet metal I can extend my ideas more effectively than would be possible in any other material.

Historically, the process most widely utilized in the joining of different units in a piece of sculpture has been heat joining. However, certain potential problems are confronted when heat joining methods are employed in the construction of sculpture. The first consideration is the choice of metals. Steel, the most common metal used in construction, presents no major problems. If a metal other than steel is to be used, specialized and expensive equipment, or very complicated processes requiring specialized materials, are needed to weld the metals. Most of the equipment and technology needed for these types of heat joining processes are not available to the average artist. A second consideration occurs

when brazing or soldering is to be employed. Brazing and soldering are processes used when thin metals are to be joined. When thin metal, even steel, is used, excessive surface warpage will occur due to heat applications, unless some type of internal structuring, such as bracing or armatures, is used to anchor the metal. The last major consideration in heat joining is the use of dissimilar metals in the same piece of sculpture. Because of the varying temperatures at which different metals melt, it is very difficult, and in some cases impossible, to join certain different metals.

The Problem

The concern in this project was the utilization of metal joining processes which used no heat in the construction of sculpture. The problem area was motivated by an attempt to avoid some of the inherent problems and limitations incurred when welding, brazing and soldering are employed. Specifically, the following questions were considered:

1) Can the non-heat joining process be utilized as a design element?
2) Does non-heat joining allow the use of lighter (30-16) gauge metal?
3) Are distortion and bracing problems reduced by use of non-heat joining processes?
4) Can more diverse metals such as aluminum, copper, brass and bronze be utilized in these processes?
5) Do these non-heat processes make allowances for

CHAPTER II

DESCRIPTION OF THE WORK AND THE WORK PROCESSES

SCULPTURE 1 — 71" x 18" x 8" aluminum

The first sculpture in the series was an aluminum wall piece. The joining process explored in this piece was pop rivets on thin gauge metal.

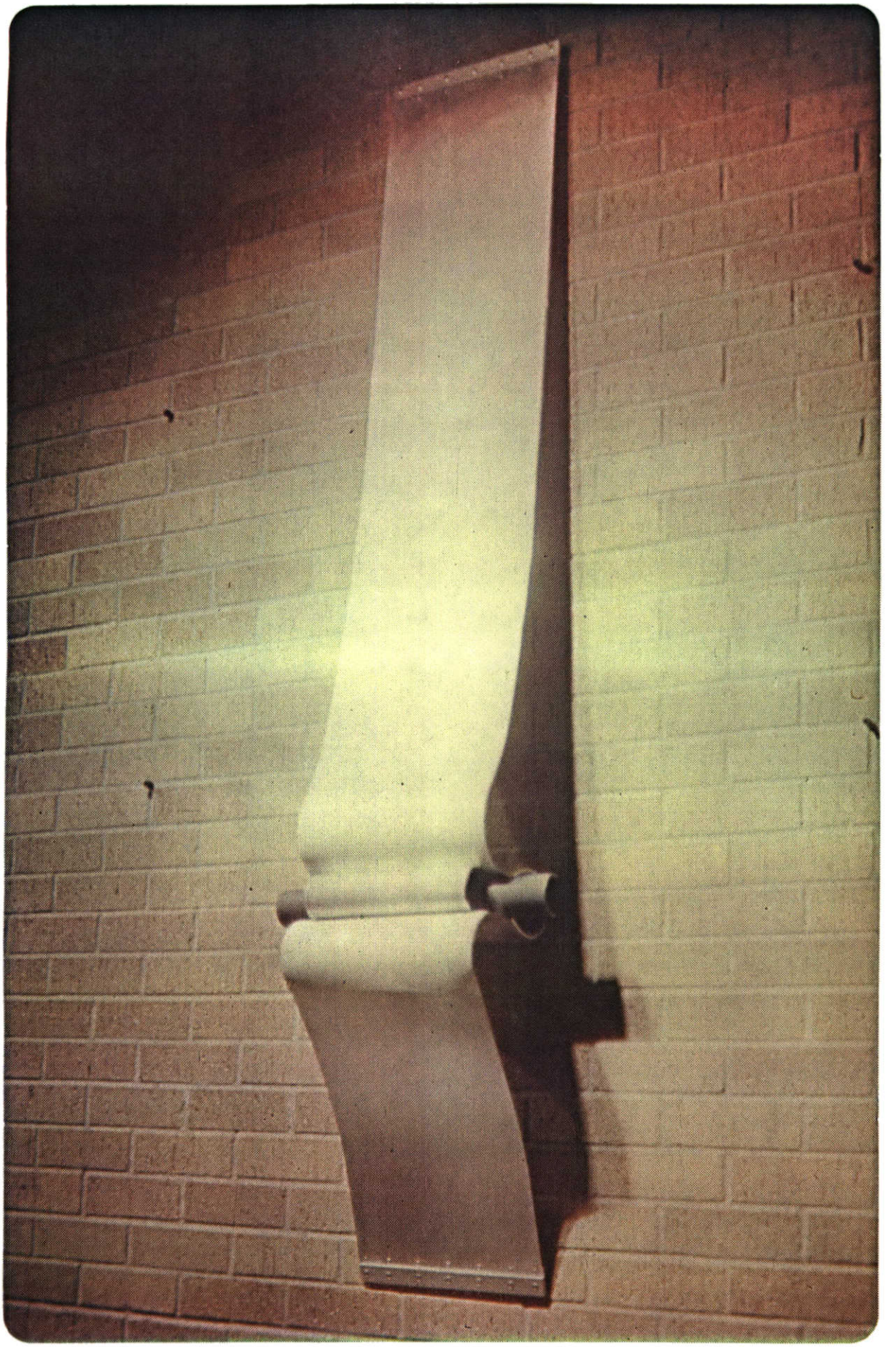
Eleven pieces of metal were used in the construction of this sculpture. The main vertical unit was fabricated from three 29" x 12" sheets of twenty-three gauge aluminum. One-eighth inch diameter pop rivets were used to join these units, thus creating one unit which was 87" x 12". Because a thin gauge of metal was used, the long unit was very flexible. It was this inherent flexibility that generated the formal considerations for the piece: take a material that is considered intrinsically rigid and make it appear soft and flexible. To achieve this visual image I decided to create a "wave" effect in the vertical unit. I accomplished this by constricting the vertical unit at two points, six inches above and below one of the riveted seams, utilizing a semi-cylindrical unit eighteen inches long with a two and one-quarter inch radius. The horizontal unit was then riveted to the semi-cylindrical unit causing the triple curve to occur. I would have stopped at

manipulation of the metal prior to the construction of the sculpture?

Methodology

A series of four metal sculptures was created to provide data relevant to the above questions. The sculptures are all wall pieces and have a relief orientation. The pieces alternate between forms which move off the wall surface and framed pieces which relate to the wall in much the same way as a painting.

Data were collected in two forms: 1) a written journal concerning technical problems and 2) photo documentation at completion. These data were analyzed in relation to the questions posed. Processes and technical problems were of importance in this project, but the primary concern was in reference to their effect on the visual aspect of the sculptures.



this point with the structural considerations for this area except for the fact that the center line of the back curve was a riveted seam. This seam did not allow the metal to maintain a continuous curve, and this fact was visually disturbing. To remedy this I inserted two curved ribs of band aluminum on the inside edges of the curve and riveted these ribs in place. These ribs eliminated the distortion problem and held the curve constant; however, I felt they were somewhat defeating, because I had hoped to eliminate bracing in these pieces and the ribs serve as bracing only. I felt that this was a problem which could have been avoided in the planning stage. If the piece had been laid out in such a way that a riveted seam did not fall in the curved area, I do not think that any additional bracing would be required.

As a final visual consideration in this curved area, a second semi-cylindrical unit, ten inches in length with a 2½" radius, was placed in front of the first unit. This unit was held in place by tension; it was wedged between the forward curves of the vertical unit.

The last units to be considered in the construction of this piece were the capping units at the top and bottom of the vertical unit. Each of these units was fabricated from two pieces of band aluminum. These pieces were joined together flush down one long edge, with three-sixteenth inch diameter pop rivets. By joining these pieces in this way there was a one-half inch lip which was placed behind the

vertical unit at both the top and bottom. These pieces were then drilled and set with one-eighth inch diameter rivets.

I feel that this piece was reasonably successful in terms of the considerations made at the beginning of the work. The use of thin gauge metal was successful in terms of reducing the weight of the finished product; the completed piece weighed less than ten pounds. Structurally, the thin gauge sheet worked, with the exception of the back curve. As stated earlier, this problem could have been eliminated in the planning stage. The only drawback in terms of thin gauge sheet in this piece was the choice of aluminum. Because aluminum is a soft metal, I had several problems with scratches and dents in the surface. In future pieces, I would utilize a lighter gauge mild steel or stainless steel sheet. There would be very little change in the color of the finished product and the piece might be slightly heavier. By utilizing a different type metal the surface would be much more durable and would require less maintenance.

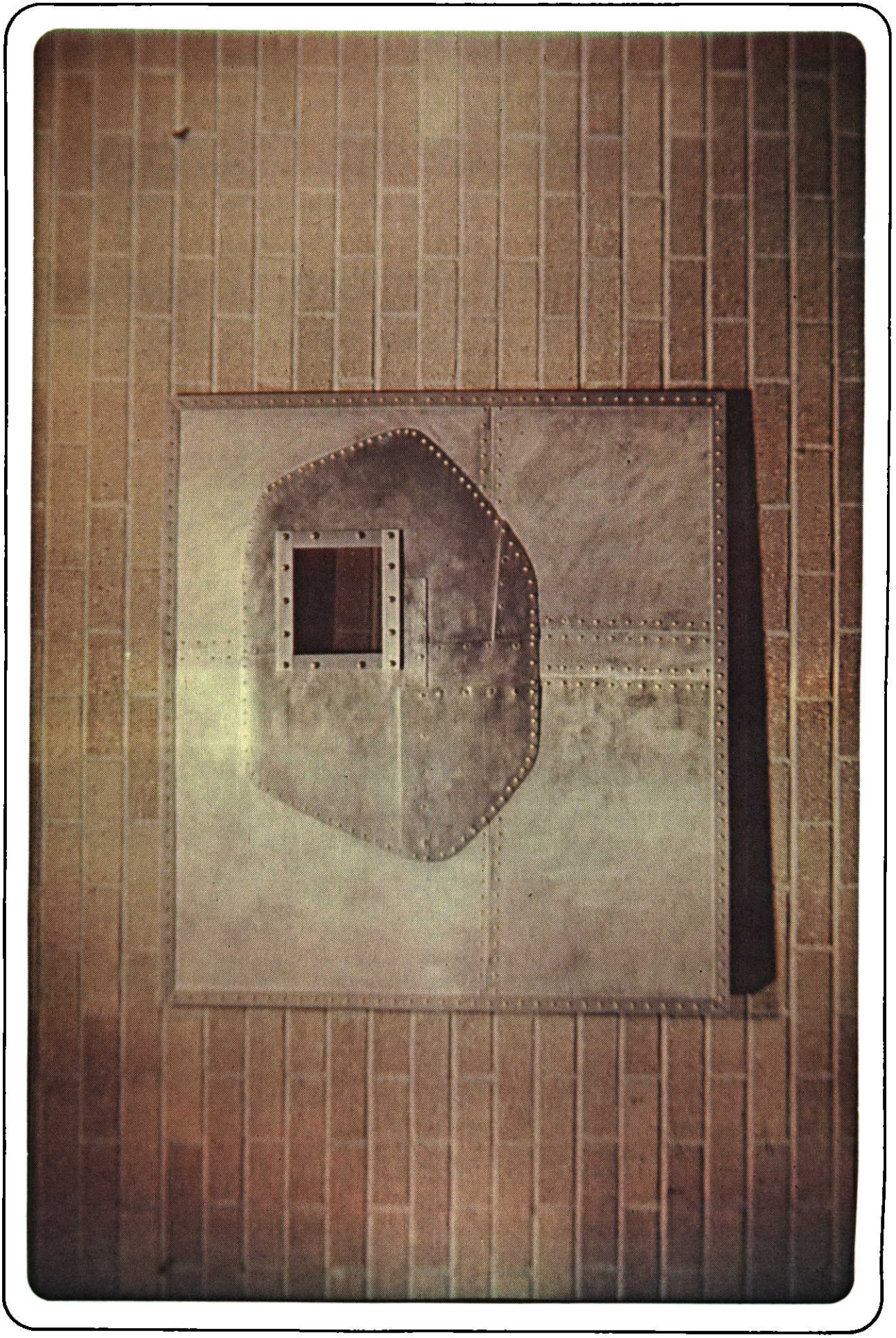
In reference to the use of pop rivets as a means of joining, I feel the piece was a success. I was quite satisfied with the rivets in terms of ease of application. I did not encounter any technical problems and I feel pop rivets are a fast and spontaneous means of joining units. This sculpture was a spontaneous piece in that I had only a very general idea of what the finished product would be like. Pop rivets lend themselves to this type of construc-

tion. All one must do is drill a hole, insert a rivet, and set it. The only equipment needed to set pop rivets is a drill and a rivet gun.

I also feel the use of pop rivets was successful in terms of utilizing the joining process as a design element. The rivet heads exposed in the capping units and on the seam in the vertical units pick up and repeat the horizontal feel of the semi-cylindrical units in the curved area of the piece. In fact, the number of rivets used in the seam on the horizontal unit is greater than it needs to be. Half as many rivets would have been sufficient in terms of joining the pieces. It was entirely a visual consideration that I arrived at the close spacing of these rivets. In reference to the capping units, the three-sixteenth inch diameter rivets used to join the two pieces of band aluminum were also a visual consideration. The heads of the three-sixteenth inch diameter rivets are almost twice the size of the one-eighth inch diameter rivets. I felt that the use of the larger diameter rivets carried a visual strength which worked with the idea of the capping units. One-eighth inch diameter rivets were used to join the capping units to the vertical piece. This was a visual consideration made to maintain uniformity in the construction of the vertical unit.

SCULPTURE 2 — 36" x 39" x 3" aluminum, brass, copper, glass

In Sculpture 2 the primary concerns were the use of



traditional rivets, domehead rivets, and bolts, and their use as decorative elements in the finished piece. This piece is constructed of aluminum with brass rivets used to join the pieces.

There are two major units which make up the total piece with a total of twenty-five pieces of metal used in the construction of the finished sculpture. The first major unit to be constructed was the raised trapezoidal shape with a rectangular opening. This unit was constructed from six pieces of fourteen gauge aluminum sheet. The profile shape and the overlapping effect were predetermined and executed from a drawing. The placement of the rivets was also predetermined.

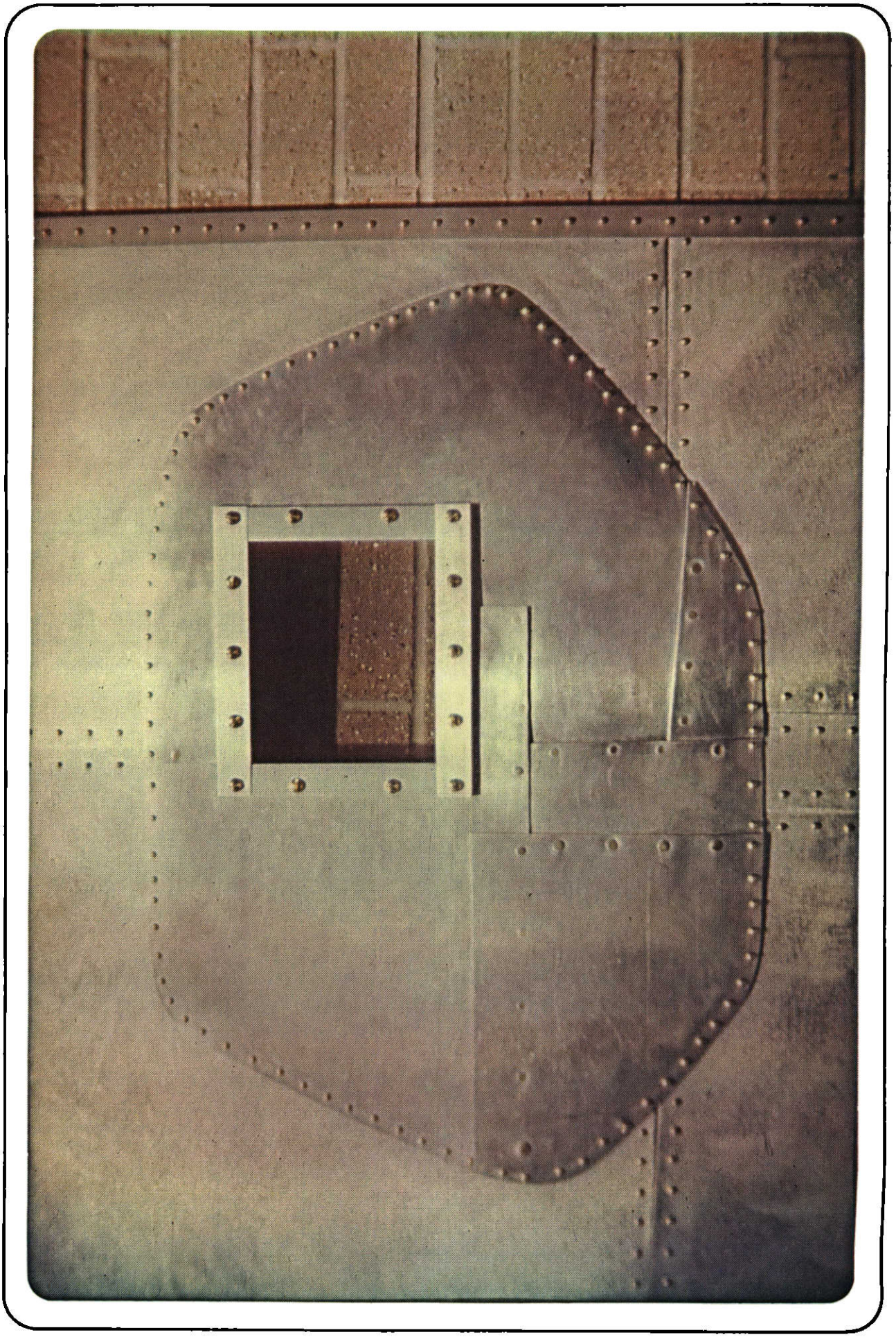
The type of rivets used in the fabrication of this unit are traditional smithing rivets which I fabricated myself. A traditional rivet is generally a length of round metal rod of any diameter. In this case, I used three-sixteenth inch diameter brass rod. The length of rod needed is determined by the thickness of the metal to be joined. After the rod was cut it was filed flat on the ends and annealed to soften the brass. Annealing was achieved by heating the rivets with a torch to a dull red color and quinching the rivets in cold water. After the rivets were annealed they were placed, one at a time, in holes which had been drilled in the overlapping sheets at the predetermined locations. The rivets were set with a hammer and an anvil.

The curved surface of this unit was achieved by hammering

the riveted unit over a round metal raising stake. A leather mallet was used to avoid excessive scarring of the surface. Some problems were incurred during this part of the construction. Due to the fact that I was not shaping one piece of metal but rather six pieces joined by rivets, the metal did not move uniformly. There was also a great deal of stress put on the riveted seams and some of the rivets pulled out. If I were to repeat this process, I would form the individual pieces before they were riveted together. Not only would the above mentioned problems be eliminated, but I feel the metal could be manipulated to a greater extent.

The rectangular opening in this unit was designed as a window. To frame off this window, four pieces of one-eighth inch by one inch aluminum band were used and these units were secured in place by one-quarter inch roundhead brass machine screws and nuts.

The second major unit to be constructed was the ground and frame unit on which the trapezoidal shape sits. This unit was fabricated from five pieces of eighteen gauge aluminum, with five strips of eighteen gauge sheets used to back the seams. The frame of this unit is made of four pieces of 1" x 1" x 1/6" aluminum angle. The ground unit was determined by laying pieces of metal around the trapezoidal shape until a pattern was established by the seams which I felt was compatible and complimentary to the first unit. In the ground unit I was interested in modifying the format by



which the sheets were joined. Rather than use an overlapping flap I chose to use a butt joint which required the use of some type of backing to which each sheet could be attached. The most direct way to solve this problem was to cut strips of metal the length of the seam and approximately two inches wide. These strips were placed behind the seams and holes were drilled through the sheet and the backing strip. Domehead brass rivets were used to attach the sheets and backing strips.

Domehead rivets were chosen to emphasize the change in the joining process and were also used to join the trapezoidal and ground units, as well as to attach the frame to the ground unit. Because the trapezoidal shaped piece was placed on top of the ground unit, I felt the use of domehead rivets in this transitional area worked effectively as they reflected the construction of the ground unit. This aspect, coupled with the lap joint that occurs at the transition and which references the construction of the trapezoidal unit, worked together to pull the two units into one harmonious unit.

The last considerations to be made in this piece of sculpture were setting the glass and attaching the etched bronze sheet behind the glass. I took what I considered to be the most direct solutions of these two problems. The glass was set in place with silicone adhesive which afforded a permanent bond of glass to metal but also allowed ease of removal in the event the glass should be damaged. To set the

etched bronze sheet, the most direct solution was to use the same brass machine screws that were holding the window frame in place.

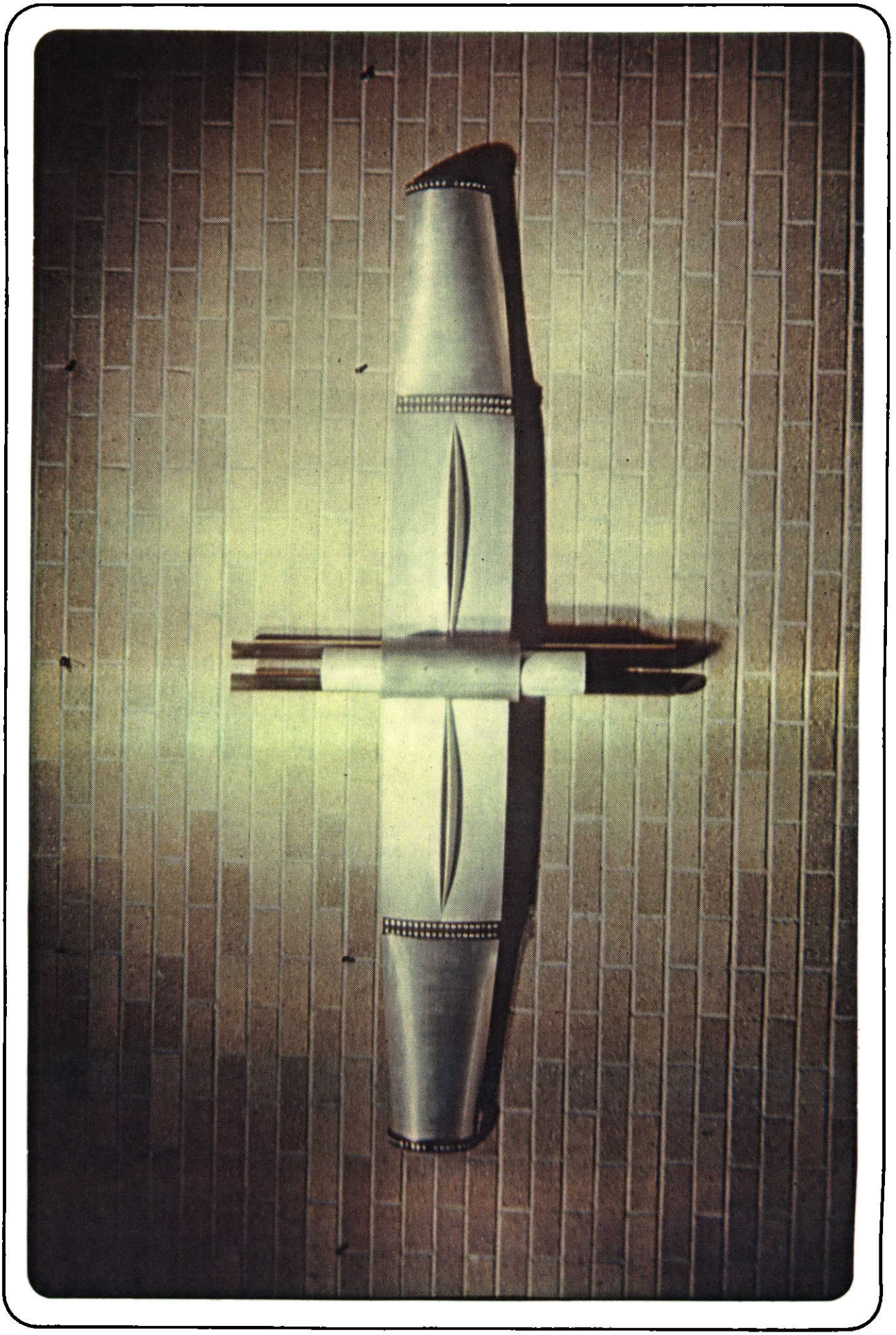
I feel that this piece is successful in terms of the use of rivets and bolts, and their use as a decorative element in the work. In reference to the use of different joining processes, I felt that the use of traditional and domehead rivets were compatible, and the machine screws repeated the domehead look of the rivets. Technically, I did not find either of the riveting processes difficult to use except in reference to the size of the piece. At times it was awkward to hold a piece this large while trying to set the rivets. With regard to the use of the rivets as a decorative element, I feel the piece was very successful. The use of brass rivets on the aluminum structure worked well in as much as the color contrast makes the rivets stand out and this emphasizes the linear patterns of the rivets. I feel that the decorative quality of the rivets was further enhanced by the surface treatment of the different units. In the trapezoidal unit the smooth lustrous surface works to emphasize the hammered texture of the traditional rivet, and in the ground unit the sanded rough surface makes the smooth round head of the dome rivets stand out. The sandblasted texture of the frame unit also contrasts the smooth domehead rivets.

SCULPTURE 3

36" x 80" x 8"
aluminum, steel,
copper, bronze,
stainless steel

Sculpture 3 is a wall piece and, like Sculpture 1, was not planned out in its entirety prior to execution. The major concerns in this sculpture were the use of several types of metal in one piece, decorative considerations of the joining process, and form considerations.

Sculpture 3 is constructed from fifteen pieces. All of the visible construction is executed with self-tapping sheet metal screws. Some of the hidden construction is executed with pop rivets. In this sculpture, as in the previous pieces, there are distinct units that are fabricated and then joined together. In this piece three units constitute the finished sculpture: the horizontal unit, the back unit, and the dual cylinder unit. The horizontal unit is constructed totally of aluminum: four pieces of sixteen gauge sheet and four pieces of band aluminum. The central portion of the horizontal unit is fabricated from two 42" x 5" pieces of sheet. The inside edges of these sheets have been formed in a wooden die to create the lip effect. These units are tied together at the ends by means of a curved rib of band aluminum. The ribs and the sheets were line drilled and connected by means of sheet metal screws. The subtle curve which occurs at the end of the sheets is caused by the curved shape of the ribs. Another row of holes was drilled in these rib units and these holes were used to



connect the next pieces which make up the horizontal unit. These pieces were two 18" x 5" pieces of sheet, and they, in turn, were capped on the outside edges with another set of curved, band aluminum ribs. These ribs were attached in the same manner as the first set and the curve of the end sheets is also determined by the curved ribs. The ribbed pieces were oxidized black to accentuate the metal screws.

The next unit to be fabricated was the back unit. This unit is comprised of two three foot lengths of one and one-half inch diameter copper tubing, two 18" x 2" strips of eighteen gauge bronze sheet, and a 4" x 5" sheet of sixteen gauge stainless steel. The piece of stainless steel acts as a central hub onto which the copper tubing and bronze sheet are attached by means of pop rivets. Pop rivets were chosen for this construction because the rivet heads are not as large as screw heads. This consideration was necessary because the back unit had to mount flush with the back of the horizontal unit in the final stages of fabrication. The bronze sheet is visible through the raised slits in the horizontal unit in the finished state. The tubing is vertical in the finished piece.

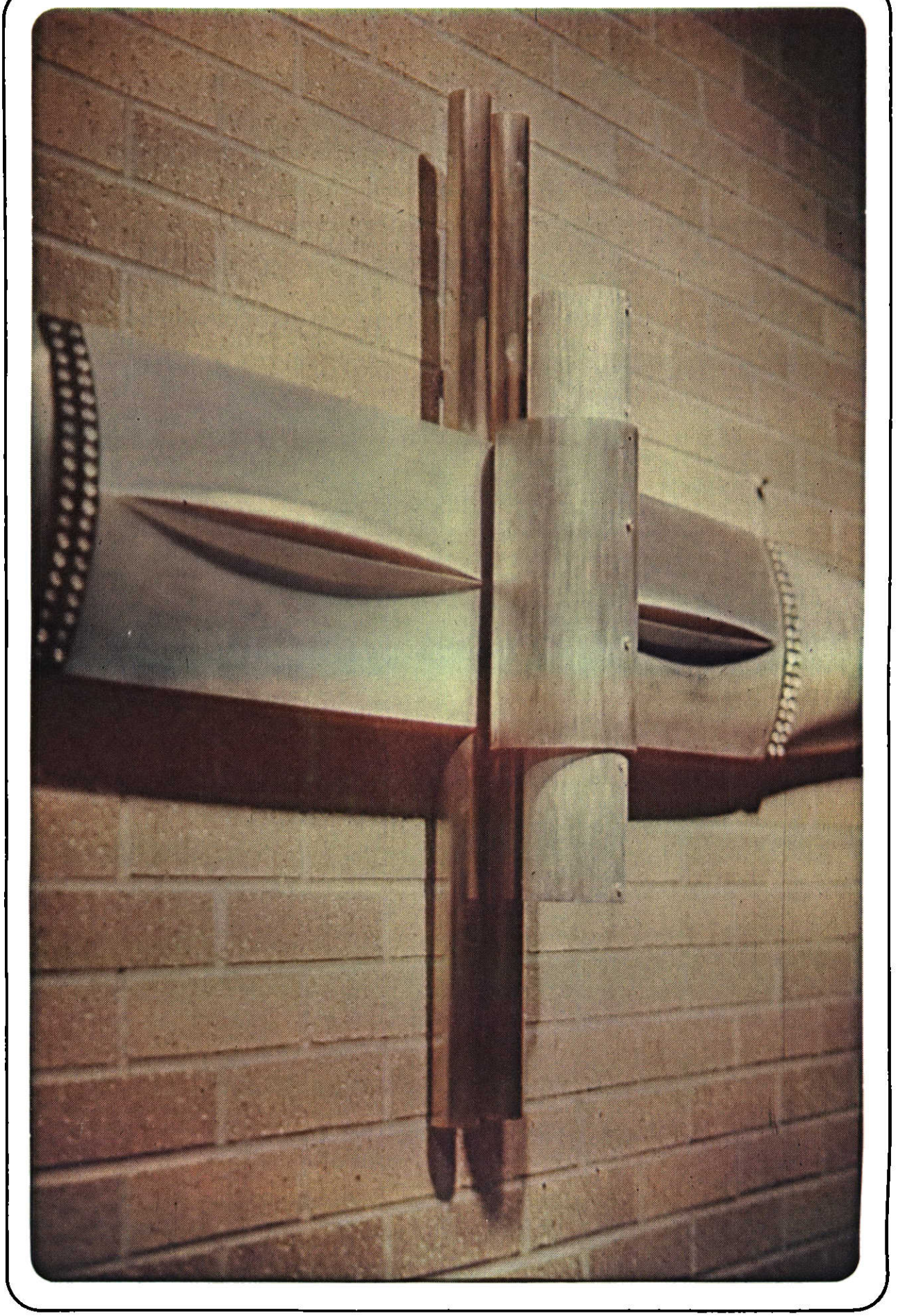
The last unit to be constructed was the dual cylindrical unit which mounts on the front central portion of the horizontal unit. This unit is constructed from a piece of five inch diameter steel tubing, eleven inches in length, and a hand formed cylinder of aluminum, three and one-half inches

in diameter and twenty-one inches in length. To form the aluminum cylinder, I took a 12" x 21" piece of sixteen gauge aluminum sheet and rolled it through a roller mill until the metal curved back upon itself. I drilled holes through the overlapping edges of the cylinder and inserted sheet metal screws. To join the two cylinders I drilled two holes in the steel cylinder which would correspond to two of the holes already drilled in the aluminum cylinder and attached the two.

At this point, construction of the three units was complete. To join the three units together, two matching holes were drilled in all three units: center of the stainless hub, center of the horizontal unit, and center line of the steel cylinder. These holes were then lined up in all three units and two sheet metal screws were used to join the pieces together. The final consideration was attaching the ends of the bronze strips which run horizontally down the center of the line of the horizontal unit. These pieces had been cut to a length which allowed them to be attached to the first rib on each side of the horizontal unit.

I feel that this sculpture was very successful not only in terms of the technical considerations but also in the formal considerations.

With regard to the use of different metals, no problems were encountered. I feel that this process is conducive to the combination of numerous types of metals. Not only does



the process allow for the combination of a variety of metals, but also for a wide range in gauges of metals as well.

The use of sheet metal screws in this sculpture did not present any technical problems. As a decorative element, the sheet metal screws were handled in much the same manner as the rivets were in the first two sculptures. Another decorative element which was utilized to accentuate the linear patterns of the screw heads was the black oxidation of specific pieces of metal in the piece. The flat black oxidized surfaces also presented an interesting contract to the polished surfaces of the aluminum.

In terms of the form considerations of this piece, I was very satisfied. To me, this sculpture was visually appealing in that it opened up into an almost linear piece and away from a confined format, unlike the two previous sculptures. I utilized the rib elements in this sculpture in much the same manner as in Sculpture 1. The ribs are exposed on the front surface so there is a very direct statement as to their purpose. The openings in the horizontal unit are elements that reflect the opening which occurs in Sculpture 2. In this piece, an attempt was made to achieve an opening in the surface which was not in need of additional pieces to cap or finish the edge of the opening and this was achieved by the direct manipulation of the sheet metal.

SCULPTURE 4

24" x 72" x 15"
aluminum, brass,
metal and cloth
zipper

In Sculpture 4 the primary objectives were to utilize thin gauge metals and joining processes not ordinarily associated with the fabrication of metal.

Sculpture 4 is made up of two major units: the base unit and the cover unit. Only eight pieces of metal were used in the construction of this piece. The base unit is constructed from four pieces of aluminum angle and two pieces of sixteen gauge aluminum sheet. The cover unit is constructed from two pieces of thirty gauge brass sheet which are joined by means of a metal and cloth zipper.

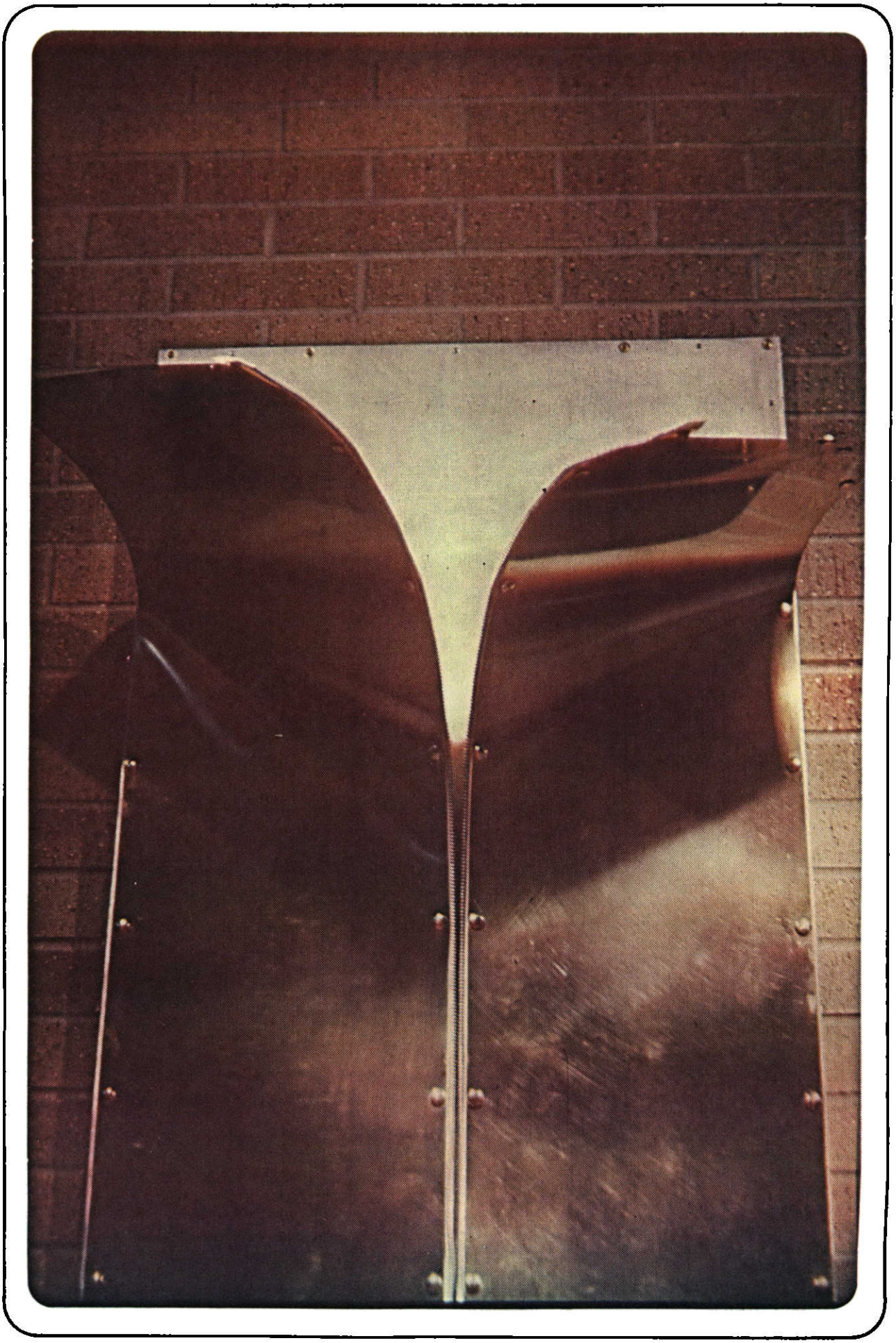
The fabrication of this piece was more simplified than the three previous pieces. The aluminum angle frame is joined by means of right angle brackets at the inside of the corners and the aluminum sheeting is attached to this frame by pop ribets. The primary visual consideration in terms of joining is achieved in the cover unit. The zipper which connects the two brass sheets is attached by means of snap fasteners and the cover unit itself is also attached to the base unit by means of snaps.

It is the use of the zipper and snaps in this piece which is important to the visual objectives set down at the beginning of the piece. In this sculpture, as in Sculpture 1, concern was with utilizing the flexibility of thin gauge metal. I feel the use of a zipper and snap fasteners enhances

this feeling of flexibility. These are joining processes which are commonly associated with fabric which is an inherently flexible material.

This sculpture, as with Sculpture 2, was totally preconceived and worked out in drawings prior to the construction of the piece. The primary idea behind this piece was to create a sculpture with the imagery of an open zipper in a piece of clothing. By utilizing thin gauge metal and a zipper which is partially opened, an attempt was made to achieve a draping open effect. This visual imagery was not achieved as effectively as I had hoped, but this was a technical problem. The problem was due to the width of the brass. The thin gauge metal used was flexible enough to allow for the draping I had wished to achieve, but if the width of each brass sheet had been increased by one-third there would have been less tension in the draping area and it would have laid open as in the original design.

In this sculpture, as in Sculpture 1, certain problems were experienced with the use of extremely thin gauge metal. Even though great care was taken in the handling of the brass sheeting during construction, bends and dents occurred in the surfaces. Another distortion problem which occurred in Sculpture 4 was in the use of snaps. Although caution was taken to align the snaps in the base and the cover units, some variation occurred. When the units were snapped together, these variations caused buckling in the brass sheeting



This buckling is visually disturbing to me and, in the future, allowances for thie type of discrepancy will be taken into consideration. After working with snaps in this piece, I have realized that these variations are unavoidable in using this type of fastener.

Although I have sounded somewhat negative about this piece, I was basically pleased with the sculpture upon its' completion. I feel that what I have learned in constructing this piece will be incorporated in my work in the future. I also feel that I have gained new knowledge of these materials and have increased my technical skills from the experience.

CHAPTER III

SUMMARY AND CONCLUSION

The series of sculptures executed in this project were centered around the concept of non-heat joining of metals. The project was concerned with both the technical and aesthetic aspects of the sculptural construction.

A number of joining devices were employed: pop rivets, traditional rivets, domehead rivets, sheet metal screws, bolts, snap fasteners and a zipper. Pop rivets were used exclusively in the construction of the first piece, and in the other three sculptures other joining devices were used in combination. Each joining device was considered in terms of its technical aspects in the fabrication of the sculpture and also in terms of the visual affect on the finished piece.

I feel that all of the pieces of this series have been successful with respect to the use of joining devices as a design element. There was no difference in the visual effect of the different devices used--all functioned as a linear pattern on the surface of the finished sculpture. Although the joining devices may seem decorative in some of the pieces, there was no extraneous use of any of the joining devices for a purely decorative reason.

The use of light gauge metal in the fabrication of these sculptures was technically no problem. In Sculptures 1 and

4 extremely thin metal was used to achieve specific visual imagery. The manipulation and joining of this thin metal was achieved without technical problems; however, there are certain visual limitations in the use of extremely thin metal in terms of surface distortion. Extreme care must be taken when handling very thin metal to avoid these distortion problems. In Sculptures 2 and 3 a compromise was reached; a light gauge metal, heavier than that used in Sculptures 1 and 4, was used. This heavier metal was structurally strong enough to eliminate the distortion problems incurred with very thin metal. After completing this series of sculptures I felt that I had familiarized myself with the distortion problems incurred in these works well enough to avoid them in the future. I feel that the non-heat joining processes successfully lend themselves to the utilization of light gauge metal in the construction of sculptures of this type.

As stated above, the distortion problems incurred in this series were not the result of the joining process but rather the use of extremely thin metal. It is my opinion that these distortion problems are minimized by the use of the non-heat joining process. In reference to the elimination of bracing, I have found that in some cases bracing of the metal is not needed. In two of the sculptures bracing was required; however, with respect to the series as a whole, the use of bracing was much less than what would have been required if heat joining processes had been employed.

With regard to the use of bracing, a personal attitude has developed as a result of this project. In Sculpture 3 I wanted to curve the vertical unit, therefore, braces were used to achieve this curve. However, rather than place them in the back of the piece I brought them to the front surface. In this way I was consciously trying to incorporate the brace into the design of the piece. My feelings were that if a brace was needed, an honest statement should be made as to what its function was. This attitude was grown out of the conscious attempt to incorporate the joining process into the design of the sculpture.

In reference to the utilization of diverse metals in this research, my feelings are that the non-heat joining processes lend themselves to the use of multiple metals in one piece. This is especially exhibited in Sculpture 3. Five different types of metal were used in the construction of this piece. No technical difficulties were encountered in the joining of these different metals, and I feel that the visual effect of using different metals is quite exciting. If heat joining processes had been employed in the construction of this piece, I feel sure that a great number of technical problems would have been encountered. The non-heat joining processes should lend themselves to the incorporation of materials other than metal into sculptures fabricated in this manner. It is my intent to pursue this line of research on my own at a later date.

The most interesting aspect of this project was in respect to the formal considerations for this series of sculptures. Most of the ideas I had about the formal direction this series would take were dropped at the time work began on Sculpture 1. Confronted with a new material and process, I reverted to a work attitude which I have used for the last three or four years: to make all of the visual decisions for the piece as the work progressed. As a result of this approach, Sculpture 1 became a wall sculpture. This was the first piece of sculpture I had constructed which related to the wall, and this sculpture was to set the direction for the other pieces in the series.

With regard to the manipulation of the metal prior to the construction of the piece, I found that no problems were incurred in the fabrication of the sculptures. The non-heat processes allowed me to form the metal units as I wished and then construct them without distortion of the formed area. This is an important finding because forming of metal creates stress in the metal, and, if heat joining processes are employed, excessive distortion can occur in these stress areas. This finding has opened up a wide range of ideas for pieces in the future which require forming of certain areas prior to the construction of the finished piece.

As a result of this project I have concluded that the non-heat joining processes used in this research have opened up a wider range of formal and conceptual directions in my

work. The non-heat joining processes, in bypassing the technical limitations of heat joining, allows greater spontaneity in the construction of sculpture. In reference to this spontaneity, pop rivets, sheet metal screws and bolts seem to work better than traditional and domehead rivets or snap fasteners, in that less time is required to join by these processes. I cannot state that one joining process is better than others, but I do think that in some types of construction of this nature one joining process may be more advantageous than another. This is dependent on the types of sculptural forms with which one is dealing. I have dealt exclusively with flat wall sculptures. In reference to these types of forms, I feel that all of the joining processes I have used can be utilized with success. If volumetric forms are to be used, I cannot say that any of the processes I have utilized can be effectively employed in the construction of a piece. This is a question I will deal with in my work in the future.

Another aspect of the non-heat joining processes which is important is the flexibility of these joining processes in the construction of a sculpture. In the heat joining processes, once two pieces of metal are joined together they are, for all practical purposes, one piece of metal. It is difficult to change or alter the form if heat joining processes are employed. In the non-heat joining processes, two pieces can be joined but they remain two pieces of metal. I used this flexibility to my advantage in the construction of several of the sculptures. In Sculputre 1 I had completed the piece

and was not satisfied with the central portion of the sculpture. Because I could easily remove the pop rivets, I completely reworked this central portion of the sculpture in a short period of time and resolved the area of the sculpture which I found disturbing.

The spontaneity and flexibility of these processes are the most important discoveries of this project. I can now, by means of non-heat joining of metals, remove much of the heavy emphasis on process and technical problems which historically have been so much a part of the sculptural process. The techniques and equipment needed to utilize non-heat processes are minimal. Therefore, I find myself less involved in the process of making sculpture and more involved in the visual and conceptual statement of sculpture.

Overall, I feel that this project has been a successful and rewarding experience. The basic questions set down at the beginning have been answered, and I have gained knowledge of new materials and processes which I will incorporate into my work in the future. This project has also opened a new direction in terms of the visual aspect of my work. I plan to pursue this line of fabricated sculpture in reference to the conceptual aspects it offers me now that I feel confident with the technical concerns of this type of construction.